Development of a National Unstructured Grid Catalog (UGC): Gulf of Mexico Demonstration[1]

Executive Summary

Through NOAA's Coastal Storms Program (CSP), an online catalog of unstructured grids used in hydrodynamic modeling projects has been proposed to document existing and future models in the Gulf of Mexico. This unstructured grid catalog (UGC) is intended to provide modelers, coastal managers, and funding agencies with a mechanism of sharing grids and information about projects to help identify modeling gaps and redundancies. A workshop was held in March 2009 to assess the community interest in the UGC and learn what types of requirements would help make this a successful project. A summary of this workshop is provided in Section 2, and specific issues raised during the discussions are documented in Section 3. Workshop participants (listed in Appendix 1) indicated that an UGC would be a beneficial resource to the community and that NOAA's CSP would be a good mechanism through which stewardship of the UGC could be initiated and maintained in the future. A key recommendation of the workshop was that an UGC working group be organized with representation from government agencies, academia, and the private sector to help guide the catalog development and encourage community participation. Next steps to be addressed by the working group and further recommendations are outlined in Section 4.

Key points about the UGC:

- The UGC will be developed as a demonstration tool for unstructured grids in the Gulf of Mexico. The success of this demonstration project will determine if the tool is expanded nationwide and if it will expand to include structured grids.

- NOAA's National Geophysical Data Center (NGDC) has developed a demonstration prototype (Section 2.4), the continued development of which will be recommended for hosting and management of the UGC.

- The UGC team will consult with NOAA's Data Management Committee for guidance on the management of the catalog.

- Initial outreach of the UGC proposal will be made to pertinent NOAA teams to coordinate efforts and encourage participation with the UGC.

- Interagency participation is key to the success of the UGC, and coordination will initially commence with the Subcommittee on Disaster Reduction's Coastal Inundation Working Group.

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- This is a community tool, and its usefulness will be measured by community participation from federal/state/local government groups, academia, and the private sector. The benefits of the UGC are aimed at coordination among the modeling community in improving access of public resources (grids) and knowledge to the end users of modeling products.

- Coordination with community modeling groups will be critical to improving the functionality of the UGC.

- Initial design of the UGC will rely on a vision of future capabilities, the incorporation of which will be easier if their functionality is accounted for in the early stages of this project.

1. Introduction

1.1 Problem Statement

Unstructured grids have been developed in the Gulf of Mexico for a variety of hydrodynamic modeling applications by different agencies, for different mandates, at different scales. Once a model study is complete, there is no central mechanism through which the grids and associated project metadata may be catalogued and potentially archived. Considering the amount of work that can go into creating high quality grids, these are valuable resources for the following reasons: (1) it is useful for communities and other modelers to know what has been developed in a given area and for what purpose; (2) shared grid resources can help reduce redundancy in development of new model applications; (3) the grids may be used and/or modified to address different purposes than how the grid was used for its original intent; (4) an unstructured grid catalog pushes forward the concept that model inputs and metadata are an important regional and national asset for identifying storm surge risk and protection of life and property.

1.2 Challenges

The primary challenge of an unstructured grid catalog is to convince modeling groups that a UGC is a valuable enough resource to warrant their participation and contribution and thus achieve long-term community benefits. A group may also be hesitant to contribute if their grids serve as an important resource in attaining future funding for modeling activities or if they are wary of how the grids may be misused. It also takes time to properly document a grid's development and pertinent metadata, so contributing to the catalog would need to be made as efficient as possible such as not to discourage participation. The grid catalog would need to address the following issues: 1) intellectual property issues such as how legal ownership and authors of a grid would be properly referenced; 2) whether modeling applications contracted by the government to the private sector would be eligible for inclusion in the catalog; 3) whether data used as input to the grid and/or model inputs may be considered sensitive (due to proprietary ownership or homeland security issues) in being carried with the grid in the shared catalog resource; 4) whether it should be designed as a catalog or as an archive for grid resources (or both); 5) what type of maintenance and

oversight would be needed to maintain and evolve a successful product; 6) establishing and maintaining communication with points of contact in key modeling groups, 7) determining what types of metadata and auxiliary data should/could be accommodated in the grid catalog, and what data would be needed to ensure the grids were useful; and 8) how should the catalogue be designed for simple and easy use to encourage participation.

1.3 Strategy

The first step towards a Gulf of Mexico UGC was to hold a workshop (funded by the NOAA Coastal Storms Program and in partnership with the Northern Gulf Institute (NGI)) involving hydrodynamic modeling groups, data archival centers, and community planners to discuss the merit of the proposed catalog and to raise issues/concerns that would need to be addressed. A demonstration tool highlighting examples of model grids that could potentially be archived provided an example starting point for the UGC. Through this the workshop coordinators solicited engaged feedback on how to proceed and obtain buy-in from groups to contribute grids.

This white paper will summarize key findings and feedback from the workshop. It will also make recommendations on the design of the project so as to most effectively address the issues of concern and incorporate recommendations from the workshop. One of the critical components of this recommended project plan will involve establishing points of contact within key modeling groups in government, academia, and the private sector through whom participation and contribution to the UGC may be coordinated throughout the length of the project. A working group will also be critical to help in the review and updating of this project plan and should be formed from NOAA personnel and the aforementioned points of contact. The project plan's milestones will be communicated to the original workshop attendees. Outreach at conferences, meetings and workshops will also be key to promoting the catalog's benefits and encouraging participation.

Development of the catalog will proceed by first consulting NOAA's Data Management Committee to make recommendations on how the management of the catalog will be handled as a comprehensive end-to-end process including the acquisition, quality control, validation, reprocessing, storage, retrieval, dissemination, and archival of the grid data. The demonstration catalog developed for the workshop by NOAA's National Geophysical Data Center (NGDC) and the Coast Survey Development Laboratory (CSDL) will be suggested as a proposed starting point upon which the UGC may be built.

2. Summary of the UGC Workshop held in Bay St. Louis, MS on March 17-18, 2009

2.1 Purpose

To introduce the idea of a UGC to the community and facilitate discussions on needs for a successful product. As reviewed in Section 3, feedback from these discussions on the challenges of the catalog project will be used to design a strategy for the development, maintenance and growth of the catalog.

2.2 Objectives

- Introduce the concept of a Gulf of Mexico UGC
- Promote the benefits of a catalog to both managers and modelers
- Highlight examples of unstructured grid modeling in the Gulf of Mexico
- Obtain buy in/commitment from the hydrodynamic modeling community
- Share examples of user needs in terms of functionality of a grid catalog

2.3 Participants

Workshop participants included representatives from federal agencies (NOAA, Navy/Naval Research Laboratory, Federal Emergency Management Agency, US Army Corps of Engineers), universities (University of Oklahoma, Notre Dame, Northern Gulf Institute, Mississippi State, Jackson State, Florida, Louisiana State, South Alabama, New Orleans), the private sector (Taylor Engineering, Worldwinds Inc., URS Corp.), and the local community (cities of Bay St. Louis and Waveland, MS). Within NOAA, representation was present from Coastal Services Center, Coast Survey Development Laboratory (CSDL), MS/AL Sea Grant, NGDC, Office of Oceanic and Atmospheric Research,   Lower Mississippi River Forecast Center, and the National Coastal Data Development Center. Many of those present had a background in hydrodynamic modeling and/or coastal storm resilience.

2.4 Demonstrations of NGDC DEM catalog and a prototype UGC, and ADCIRC Grid Database developed by the University of Oklahoma

In preparation for the workshop, NGDC developed a prototype catalog to demonstrate potential options for the functionality of a UGC. The UGC could either grow as a catalog with links to grids/projects, as an archive of grids and project metadata, or a combination of both. To demonstrate the former, NGDC set up a catalog using an ArcIMS map interface. This allowed a user to interactively view the geographic extent of different types of modeling projects. It also allowed for listing of basic metadata and links to external web pages that host additional information about the selected grids/projects. NGDC also set up a demonstration archive. This included a main webpage showing geographic extents and listings of grids and links to individual grid pages. This provided more extensive descriptions and links to full metadata and downloading of the archived grid. NOAA's CSDL worked with NGDC on the initial grid population of these two demonstration prototypes and suggested draft metadata. The following links may be used to view the catalog and the archive demos:

Unstructured Grid Catalog (*catalog*):
http://map.ngdc.noaa.gov/website/mgg/unstructured/
Unstructured Grids Project (*archive*):
http://www.ngdc.noaa.gov/mgg/csdl/

The concept and implementation of an UGC is not new, as an Advanced Circulation (ADCIRC) model grid database was set up a few years previously by Dr. Randall Kolar's group at the University of Oklahoma (OU). Dr. Kendra Dresback from OU attended the workshop and presented the work that had previously been made in the development of this ADCIRC grid database. Descriptions of metadata and the searchable database were provided, outlining ways in which users could submit grids and metadata records for

inclusion. The OU project encountered challenges associated with encouraging contribution of grids and long term maintenance. A link to the database project follows: http://coecs.ou.edu/soonercity/ADCIRC/ADCIRC_database.php

The NGDC/CSDL demonstration and OU ADCIRC grid database provide a solid foundation upon which to build the Gulf of Mexico UGC. As discussed in Section 3, feedback from the workshop will be helpful in designing a long term strategy for the development and population of the UGC.

2.5 Community response to the UGC concept

Response from the workshop participants was encouraging. Consensus was that a UGC was feasible and would provide many benefits to the user community. Participants indicated that for the UGC to be successful in its development and implementation, nine critical issue need to be addressed. These include:

- defining the UGC purpose,
- identifying the UGC audience,
- determining whether to design a catalog or an archive (or both)
- determining whether additional data and tools used in building a grid should be identified and/or included in the UGC
- whether access should be monitored and regulated
- addressing the intellectual property issue
- encourage participation through continued maintenance and outreach
- defining what metadata to include to properly document a grid/project
- and defining full metadata description options consistent with Federal Geographic Data Committee (FGDC) standards and associated FGDC searchable metadata engines

These issues will be discussed in more detail in the next section.

While feedback from the workshop participants was positive, the primary challenge and measure of success will be participation in the UGC project through contribution of grids and use of the UGC. Many levels of details were discussed at the workshop, but future contribution to the project hinges on designing a catalog that is easy to use, easy to contribute to, and captures quality information about the grids and their use. A general consensus was attained that initial participation from a core set of modeling groups could provide the momentum to demonstrate the benefits of the UGC and encourage further participation from other modeling groups.

3. UGC issues raised at the workshop

3.1 Purpose

Defining the purpose of the UGC is key to communicating to the user community why this is a useful product, not only to use but also to make grid contributions. The primary purpose of this project is to provide modelers, coastal managers, and funding agencies with a mechanism of sharing grids and information about projects to help identify

modeling gaps and redundancies. This, in turn, will provide the user community with improved access to the benefits of hydrodynamic model applications and a mechanism through which the science behind these applications can be expanded and enhanced. The UGC intends to make a first step towards answering the question, "How can the hydrodynamic modeling community move beyond the 'stovepipe' approach of developing applications that overlap in geographic extent, resolution of physical processes, and intended purpose towards a framework that facilitates improved coordination and advancement of the science provided to the public?" Hydrodynamic modeling grids, geospatial footprints of the projects for which they were designed, and accurate metadata descriptions can potentially serve as a catalyst to address this question. It will allow users to collectively understand what is available from the modeling community and how to drive the design of the parts to be greater than the whole.

The UGC can serve this purpose first by revealing what modeling applications have been developed in what region and for which purpose. This resource will allow both the end users and the modeling community to identify gaps in modeling capabilities for communities in the Gulf of Mexico. Such gaps may relate to the geographic extent, the resolution of the grid, and/or the purpose of the model application. By providing either the grid or the metadata about projects in a given region, the UGC can thus serve as a mechanism to design strategies for filling modeling gap needs. These strategies will encourage collaboration and/or referencing to the authors of catalogued grids and model applications. The net result will be a process through which modeling applications can build upon each other, enhancing and expanding the utility provided to the public. The UGC also provides the modeler with a formal archival process through which to close out a modeling project through thorough documentation and possible contribution and sharing of the grid, thereby making the grid available for posterity.

For the modeling groups, the UGC could assist in improving existing grids and in improving models through Model Evaluation Environments (MEEs). The former could be achieved through feedback mechanisms in the UGC whereby local communities and other modelers offer suggestions to the grid author on potential improvements. A MEE is defined here to consist of sufficient data and information to *configure*, i.e., shoreline, bathymetry; *execute*, i.e., model initialization, and specification of synoptic environmental conditions at lateral open-ocean boundaries, river discharges, and at the air-sea interface, and *determine model uncertainties*, i.e., observations of water levels, currents, and salinity/temperature. These MEEs could be set up more readily to use a contributed grid for evaluating the performance of different models. MEEs are an evolving concept that has been developed in some preliminary regions, and the UGC could help to extend this concept more systematically and comprehensively. The UGC may also facilitate other uses of a grid to address a need or purpose not intended by the original project, thus encouraging cross-field collaboration.

As most coastal and estuarine modeling projects are government funded, it is reasonable to look to frameworks such as the UGC to provide a roadmap for future planning of modeling projects. The purpose of the UGC may evolve to help reduce "stovepipe" and redundant applications, help identify modeling gaps/needs, and promote more emphasis

on the improvement of science and products delivered to the public. An UGC that has participation from core federal modeling groups, academia and the private sector will exemplify to the public and federal leadership that there is a consistent and well thought out evolution in the story being told and written by the various modeling projects funded through the same source.

3.2 *Who is the audience?*

The intended audience includes hydrodynamic modelers, coastal engineers, coastal managers, and coastal ocean science program managers. Depending upon the types of UGC data linkages, the audience may also include data archiving groups and data collectors. A successful UGC could also complement education and training opportunities with communities in the Gulf of Mexico. One suggestion made at the workshop was to examine the user community of the tsunami Digital Elevation Model (DEM) database maintained at NGDC.

Specific groups suggested at the workshop who could potentially be users as either modelers or coastal/program managers included NOAA, USACE, FEMA, USGS, EPA, Navy, NASA, Integrated Ocean Observing System (IOOS) regional associations, Department of Homeland Security/Coast Guard, Minerals Management Service, academia, state and county agencies, local regional planning councils, regional water management districts, port authorities, private consultants (modeling and engineering), and oil companies.

The composition of the user community would be dependent upon the content of the UGC. Consensus from the workshop indicated that a UGC working group be formed with representation from core modeling groups to guide the design of the content of the UGC and to provide guidance and assistance in outreach to promote the UGC project. This working group could potentially be streamlined as part of an existing interagency working group, for example the Coastal Inundation Working Group (CIWG) under the auspices of the President's National Science and Technology Council/Committee of Environment and Natural Resources/Subcommittee on Disaster Reduction (SDR). Building a feedback mechanism is important through which users could easily make recommendations on how the UGC could be adjusted to meet their needs. The working group would then be able to review these recommendations and request UGC developers to make necessary changes.

3.3 *Catalog and/or grid delivery/archive issues*

In the UGC demonstration prototype, two options were presented for its future design . In the first option, the UGC would serve as a geospatial catalog listing of grids and their associated metadata. Geospatial footprints and/or images of grids would be provided to give users a sense of their geographic extent and horizontal resolution. The catalog option would allow the user to follow links to an outside host webpage/URL related to that modeling project and grid. The respective web host would then control the level of access to the grids, metadata and contact information for collaboration. The catalog option allows the participating modeling groups more flexibility with regards to intellectual property concerns and how the grids might be used by others. It also allows the catalog to

document the project for the user community's awareness of its geographic extent, model purpose, and associated metadata. One issue with a catalog is that maintenance would be required to periodically ensure that links/URLs were still valid to external project webpages. Another issue is that each web host would need to decide on whether or how to archive their grids for long-term management and posterity.

The second option for the UGC is to serve as a grid-delivery mechanism through which grids and their metadata could be searched and retrieved. This option would require a conduit through which modeling groups could contribute grids and metadata to the UGC. The conduit could be a person to whom grids/metadata are submitted, an automated online submission form, or a combination thereof. The UGC working group would need to decide the level of quality control, if any, needed to evaluate contributed grids before archiving in the UGC, and who would perform such QC. The UGC developers would then maintain the grids/metadata in their database unless removal is requested by the grid author due to obsolescence or other reasons. Two primary benefits of the grid-delivery option are long-term archiving of grids and metadata, and relieving contributors from having to maintain their own grid web site, or responding to grid requests from interested parties.

A third option is for the UGC to have functionality of both the catalog and the grid-delivery/archive. This option would allow the grid developer the choice of how to participate in the UGC and could encourage more participation than if the UGC were solely a catalog or a grid-delivery/archive. This is the ideal option, if feasible and cost-effective, as the key challenge to achieving the purpose of the UGC is for groups to actively participate at their comfort level.

3.4 Underlying data and tools

Data pertaining to bathymetry, datums, shoreline and engineering structures are all used to generate unstructured grids. The development of the UGC should consider how much information related to these source data should be included in the catalog. At a minimum, the UGC should have metadata fields for capturing what source data was used in grid development. Discussions at the workshop addressed whether source data might also be included in the UGC, either as archived data or as links to outside sites. We recommend in the first phase of UGC development to not try to archive these source data, but rather to capture information about the data in metadata records. Links to outside data sources could likewise be provided in the metadata. It is expected that most types of source data already reside in federal archive data repositories.

The metadata should allow users the capability of describing their model simulation in addition to the information about the grid and grid development. There are many other input files needed for simulations that describe model parameters and boundary forcings. Workshop participants discussed whether these files should be considered for inclusion in the UGC. One scenario would be to build the UGC grid-delivery to allow contributors to include these files, if desired. For example, a contributor may first select the model and version used for their simulations from a pull-down menu. Based on this selection, another pull-down menu would allow users to select which input files to include in

addition to their grid. They would then be allowed to enter basic descriptions and upload such input files.

It is recommended here that the UGC start with a focus on grids and metadata pertaining to their source data. The UGC working group should then discuss the possibility of expanding to include other model input files. How much the UGC is designed to expand to potentially include further input files and source data will hinge on the UGC developer's evaluation of technical/resource limitations and UGC working group decisions. Another important issue is possible intellectual property infringements. Examples of data that may have certain proprietary limitations could include atmospheric data/forecasts, certain bathymetric/lidar data, land use data, and other boundary forcing information. When a user is contributing a grid, a disclaimer should provide warning that there are no intellectual property infringements with the source data used in developing the grid, or that the grid has restrictions.

In the UGC prototype demonstration, main page links were provided to key bathy/topo data sources, tools and model webpages. Preliminary model links included the ADCIRC, Finite Volume Coastal Ocean Model (FVCOM) and Semi-implicit Eulerian Lagrangian Finite Element (SELFE) community model pages. Links to tools could be followed to resources such as VDatum (NOAA's vertical datum transformation software), Gridscope (ADCIRC grid editing tool developed by Notre Dame University), SMS (unstructured grid editing software, Surface Water Modeling System), xmgredit (grid editing software from Oregon Health and Sciences University), and more. Links to bathy/topo data could include sites hosting such data in a reliable and systematic manner. The UGC web site could be designed to have links to tutorials on tides, storm surge, vertical datums, and other topics relevant to the grids and the purpose for which they are created. The UGC working group should determine the extent of these links that can be maintained in a reliable manner.

3.5 Access issues

One of the factors influencing the level of participation in the UGC will be the ease of access in contributing and downloading grids. It is important to build into the UGC the capability of allowing various levels of metadata input accompanying a submitted grid. Some basic, minimum level of required metadata input will be required. Beyond this, the user will be free to submit as much information as they wish. There should also be a way for users to submit FGDC-compliant metadata records. Contact information will be required with each submitted grid, although the UGC developers should be mindful that this can become out of date. Alternate contact information and/or links to the sponsor/manager of the project may help alleviate this issue.

Searching the geospatial catalog using visual footprints of the grids is a useful way for users to interface with the UGC. These footprints could be shown in various categories related to projects, agencies, and modeling purposes. Examples of the latter could include storm surge, waves, tides, currents, hydrology/design, planning and search/rescue. If possible, there should be a way the user can view a grid in more detail through some "zoomable" function. Access to the grid itself will require definitions of formats for the

grids. It is recommended that the UGC working group work with the unstructured grid model developers (ADCIRC, FVCOM, SELFE) to document the recommended grid file formats. There is also a working group between these three modeling communities to develop a common netCDF standard grid format for unstructured grids. Therefore, a representative from the UGC working group should participate in those discussions to see if this may be incorporated into the catalog.

One of the more important access issues for the UGC is how to monitor use of the grids and standard procedures for grids to be referenced if used by another group. Should there be mandatory or recommended procedures for referencing use of UGC grids? Should users be required to sign some form of user/license agreement? What types of disclaimers need to be posted on the UGC? Should there be "controlled access", such that users will need to register with the UGC manager to obtain account and password before accessing the UGC, or should the catalog be freely open to the public? These are all questions that need to be answered through discussions in the UGC working group. The simpler these procedures the better, although development of the UGC needs to evaluate these issues carefully.

3.6 Intellectual property

A key issue in the UGC development is how to effectively attach authorship to a grid and establish guidelines for future citation of the grids. Modeling groups and researchers will be more likely to contribute to the UGC if they know that the grids will be properly referenced in any work derived from a contributed grid. One possible mechanism for addressing this issue would be maintaining version control of submitted grids. The grid catalog effort does not intend to make any requirements for contributing grids, as each group should participate at their own level of comfort. However, if the UGC concept is to be successful, there needs to be a push for acknowledgment that the grids are resources (mostly) developed from federal funding and should therefore be accessible to the public, whether through an archive or a catalog to more information regarding a project. Exceptions to this philosophy would primarily be related to grids developed for the military with sensitive defense and/or homeland security information. Grids developed by the private sector could be considered a resource belonging to a company, but participation in the UGC would still be encouraged through the catalog option linking to further project information.

While most grids are developed through federal funding of some sort, the purpose of the funding is not merely development of a grid but to develop model simulations addressing a particular issue. Therefore, groups will need appropriate time to make thorough analysis of model results and publication of their work. Federal groups that contract work out to universities and/or the private sector will need to examine whether the grids developed for the project may be considered to be owned by the federal group. If there is some question in these regards, future contracts may consider contractual statements of work to include transfer of the grid to the funding agency. As mentioned earlier, contribution of a grid to the UGC could be a effective method for closing out and archiving a federal project.

The UGC working group will need to determine if users downloading grids from the catalog would need to agree to some type of license/user agreement. This would involve coordination with NOAA's legal guidance team, and the working group will need to evaluate if this would be useful or more of a hindrance to community participation in the UGC. Another option would be some type of tracking and/or reporting mechanism for users of downloaded grids to provide feedback to the original grid authors on the manner in which they are using the grid. Disclaimers will also need to be addressed by the UGC working group. For example, the UGC demonstration prototype had a preliminary disclaimer about the grids not being used for navigation purposes. The most important factors to keep in mind with any user agreements, feedback mechanisms, and disclaimers is that the UGC needs effective ways for users to reference the originating grid work and the authors need effective ways to follow the status of any work derived from their grids.

3.7 Maintenance & outreach

General agreement was attained at the UGC workshop that a federal agency should host the catalog and that it should be maintained by a working group represented by a core set of modeling groups from several federal agencies. As the UGC concept fits within the mission of NOAA, it is recommended that progress towards an operational UGC proceed under the auspices and guidance of NOAA's Coastal Storms Program (CSP), NOAA's Storm Surge Team, and the SDR Coastal Inundation Working Group. CSP representatives will coordinate with NOAA's Data Management Committee to determine which NOAA data archive and access site will host the UGC. NGDC will be recommended as the host site based upon its work on developing the demonstration prototypes and its commitment to long-term maintenance of data/resource delivery tools.

A working group will be initiated from a core set of federal modeling groups from NOAA, USACE, Navy, FEMA and USGS. Representatives from universities and the private sector will also be contacted to solicit participation on this steering committee. CSP and NOAA's Storm Surge Team representatives will investigate whether the UGC interagency working group may strategically align within the SDR Coastal Inundation Working Group.

In addition to encouraging participation in the UGC from their host agencies/groups, the steering committee will make recommendations on the design of the catalog and will promote scientific review of the content. The committee and the hosting site should maintain a focus on maintenance and a vision of how the catalog will look and function not only now but also 5-10 years in the future.

Outreach of the Gulf of Mexico UGC will be managed through CSP team members from NOAA's Coastal Services Center (CSC) and the Mississippi-Alabama Sea Grant Consortium. This outreach should be coordinated with regional groups/associations in the Gulf of Mexico, including the Northern Gulf Institute, MS/AL Sea Grant, the Gulf of Mexico Coastal Ocean Observing System (GCOOS), Centers for Ocean Sciences Education Excellence (COSEE) Central Gulf of Mexico center, and other pertinent regional groups.

3.8 What information/metadata to capture for searching of catalog?

Metadata describing the grids and their modeling purpose will be key to the functionality of the UGC. An option for the user to submit FGDC-compliant metadata records will be available to users, and there will be systematic ways to document the grids with modeling-specific metadata questions/forms. The types of data collected from such metadata will be used to develop search criteria and keywords that could be used for users to sort through the catalog's grids. Such metadata and search criteria were developed in the ADCIRC grid database developed by the University of Oklahoma, and therefore the UGC developers will coordinate with that group on implementation of such features. Decisions will need to be made with respect to which metadata fields are required, which are recommended, and which provide useful additional information but are not required.

Examples of model-specific metadata that will be useful to capture include nearshore and open ocean grid resolution, a geospatial footprint of the modeled region, the purpose of the model application for which the grid was developed, the model used in that application, the sponsoring agency and/or project, horizontal and vertical datums, number of nodes/elements, and more. We propose that a preliminary list of model-specific metadata questions be distributed to all of the UGC workshop participants along with a solicitation for suggestions on further metadata that would be useful. The UGC working group will then make decisions on the final set of metadata that will be built into the first version of the UGC. There should also be a feedback mechanism on the UGC site that allows future suggestions to be made by the user community.

3.9 FGDC metadata and links to searchable metadata engines

The FGDC is tasked with developing procedures to assist in the implementation of a distributed discovery mechanism for national digital geospatial data. Geospatial metadata are the building blocks through which this can be accomplished, and development of the UGC should encourage FGDC-compliant metadata records for unstructured grids. This may be done by providing links on the UGC site to FGDC standards and metadata software tools. Standard templates could also be provided in the UGC that would allow users to easily fill in key information needed by FGDC requirements. We recommend that development of FGDC-compliant metadata be encouraged but not required to submit a grid, and that tools/templates be provided to assist users develop such information if desired.

For those grids that are submitted with FGDC-compliant metadata, the UGC site should have the capability to link these to FGDC searchable engines. For example, metadata could be fed into the National Ocean Service's Data Explorer (http://oceanservice.noaa.gov/dataexplorer/) to allow users to search data holdings, view metadata, and link to and/or download specific data sets using interactive mapping tools. NOAA's National Coastal Data Development Center also has a Metadata Enterprise Resource Management Aid (MERMAid) that will facilitate publishing of complete records to a variety of FGDC-based repositories (e.g., NSDI, GOS, PHINS, NBII, etc.). These types of FGDC metadata search engines and publishing tools should be considered by the steering committee in the development of the UGC.

4. Recommendations for near term next steps with the UGC

4.1 Startup of the UGC: Planning decisions

- Progress towards an operational UGC should proceed under the auspices and guidance of NOAA's Coastal Storms Program (CSP), NOAA's Storm Surge Team, and the SDR Coastal Inundation Working Group.

- Distribute this white paper to NOAA program and modeling teams for review and comment.

- Re-distribute a revised draft of the white paper to workshop attendees and other key points of contact.

- Finalize the white paper.

- Consult NOAA's Data Management Committee to make recommendations on how the management of the catalog will be handled and where the UGC site will be hosted. Based on its experience in developing DEM archives/catalogs and the UGC demonstration prototype, NGDC will be recommended as the UGC host site.

- Establish a point of contact within NOAA, USACE, FEMA, Navy, and USGS to serve on the UGC working group. The POCs will be responsible for encouraging participation and/or contribution in the UGC with modeling groups within their organizations. The POCs will also evaluate any intellectual property issues that may be specific to their organization.

- Solicit participation in the steering group from all other modeling groups represented at the UGC workshop.

- Contact the coordinator of the SDR Coastal Inundation Working Group to evaluate whether it makes sense to incorporate the UGC working group as part of that effort.

- A preliminary list of suggested model-specific metadata will be distributed to all of the UGC workshop participants along with a solicitation for suggestions on further metadata that would be useful. The UGC working group will then make decisions on the final set of metadata that will be built into the first version of the UGC.

4.2 Initial Design of the UGC Website

- Coordinate between the UGC developers and the University of Oklahoma ADCIRC grid database on evaluating model-specific metadata, criteria for sorting through grids, and searchable keywords for the UGC database.

- Examine the user community of the tsunami DEM database maintained at NGDC and assess how the UGC may be tailored based on that project's experience.

- Develop the UGC as a grid-delivery and a catalog, both options being available to users from a common UGC home webpage.

- Build into the UGC the capability for a feedback mechanism through which users could easily make recommendations on how the UGC could adjust to meet their needs.

- Use the NGDC demonstration prototype as a starting point for development of a Phase I UGC in the Gulf of Mexico. Development should start with a focus on the grids and metadata pertaining to their underlying data, geographic extent and resolution, and the modeling application.

4.3 UGC Working Group Issues to Address

The UGC working group and UGC host site will convene regular teleconference meetings to address the following issues:

- Determine the mechanism through which grids could be submitted to the UGC, if grid-delivery and archiving is a chosen option.

- Determine funding sources for the user community.

- Determine whether other model input files and/or parameters should be included in the UGC.

- Evaluate what links to data and tools should be included on the UGC web site.

- Determine an approach for working with the unstructured grid model developers (ADCIRC, FVCOM, SELFE) to document the recommended grid file formats. Investigate forums for development of netCDF formats that are universal to multiple unstructured grid models.

- Address the following questions: Should there be mandatory or recommended procedures for referencing use of the UGC grids? Should users be required to sign some form of user/license agreement? What types of disclaimers need to be posted on the UGC?

- Address the following questions: What are the intellectual property issues of grids developed for projects sponsored by each group/agency and recommendations for how to address such issues. Shoud memorandums of agreement be considered for future collaboration?

- Make recommendations on the design of the catalog and design a process for scientific review of the content.

- Evaluate FGDC metadata options and links to FGDC search engines.

4.4 Planning for Future Years

- Establish milestones and a timeline for development of a Phase I, II, and III UGC and distribute to the UGC workshop participants.

- Develop outreach mechanisms through NOAA's Coastal Services Center, the Mississippi-Alabama Sea Grant Consortium, and regional associations in the Gulf of Mexico.

- Examine the possibility of expanding the UGC 'Gulf of Mexico' to other geographic regions and the inclusion of structured grids/models.

4.5 Projected UGC Activities in FY09 and FY10:

- 4th Quarter FY09: In consultation with CSDL and NGDC, NGI will coordinate with the National Data Center Management Committee to determine the best approach for hosting the grid catalog/software. This will include organizing an implementation workshop between the Management Committee, potential hosting entities, and the project team to review status and recommendations, establish roles and responsibilities, and develop the long-term maintenance plan.

- 1st Quarter FY10: CSDL and NGDC will define an initial set of metadata requirements, ties to databases (bathymetry/topography/shoreline/VDatum), and grid formats for input to the catalog database.

- 2nd Quarter FY10: CSDL and NGDC will transition the prototype demonstration to operations, incorporating the functional requirements feedback/input from the workshop and modeling community. Establish final grid formats, metadata fields and database linkages (bathymetry/topography/shoreline/VDatum) for the grid catalog.

- 3rd Quarter FY10: review the catalog's functionality and usability; make recommendations for necessary adjustments to the catalog.

- 4th Quarter FY10: Populate the grid database with contributions from government, university, and business participants. For Phase I, grid population will be focused on the Gulf of Mexico region.

Appendix 1. March 2009 Unstructured Grid Catalog Workshop Participants

Organizers and Facilitators:

- Tina Sanchez, NOAA Coastal Services Center
- Lindy Betzhold, NOAA Coastal Services Center
- Audra Luscher , NOAA Coastal Services Center
- Tracie Sempier, MS/AL Sea Grant
- Katie Breath, Nution LLC
- Ann Weaver, NOAA Coastal Services Center

Participants

- Frank Aikman, NOAA Coast Survey Development Laboratory
- Cheryl Ann Blain, Naval Research Laboratory
- John Brock, USGS Coastal and Marine Geology Program
- Mike Carron, Northern Gulf Institute
- Jim Corbin, Mississippi State University

- Himangshu Das, Jackson State University
- Todd Davison, NOAA Coastal Services Center
- Kendra Dresback, University of Oklahoma
- Barry Eakins, NGDC NOAA CIRES
- Pat Fitzpatrick, MS State University
- Mrs. Garcia, City of Waveland
- David Garcia, City of Waveland
- Ioannis Georgiou, UNO
- Lei Hu, Dauphin Island Sea Lab
- Robert Jacobsen, Taylor Engineering
- Benjamin Jelley, Worldwinds Inc.
- Julien Lartigue, OAR/NOAA
- Gene Longenecker, DHS/FEMA Region IV/Mitigation
- Robert Lowe, DHS/FEMA Region IV/Mitigation
- Doug Marcy, NOAA Coastal Services Center
- Hassan Mashriqui, NOAA Office of Hydrologic Development
- Edward Myers, NOAA Coast Survey Development Laboratory
- Alan Niedoroda, URS Corp Water Resources Group
- Rachael Nowlin, Dauphin Island Sea Lab
- David Ramirez, NWS/NOAA Slidell WFO
- Jay Ratcliff, US Army Corps of Engineers
- Dave Reed, NWS/NOAA Slidell WFO
- Jay Ritchie, Northern Gulf Institute
- Ilya Rivin, NCEP NOAA Environmental Modeling Center
- David Sallis, NCDDC/NOAA
- Peter Sheng, University of Florida
- Robert Twilley, Lousiana State University
- Elizabeth Valenti, Worldwinds Inc.
- Ty Wamsley, US Army Corps of Engineers
- Bret Webb, University of South Alabama
- Johnathan Westcott, DHS/FEMA
- Joannes Westerink, University of Notre Dame